THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	: Examiner: Hien Ngoc Nguyen
Martin O. Leach et al.	:
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Application No. 10/551,585	:
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For: CORRECTION OF GEOMETRIC DISTORTIONS IN MAGNETIC RESONANCE IMAGES	:

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I hereby certify that this Correspondence is being filed on September 30, 2010 with the United States Patent and Trademark Office via the EFS filing system.

AMENDMENT AND REQUEST FOR RECONSIDERATION UNDER 37 CFR 1.116

Dear Sir:

In response to the Final Office Action mailed July 7, 2010, please consider the following amendments and remarks.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 13 of this paper.

AMENDMENTS TO THE CLAIMS

Please amend the claims to read as follows.

1 – 56. (Cancelled)

57. (Currently Amended): A method of acquiring and processing Magnetic Resonance Image (MRI) data from Nuclear Magnetic Resonance signals generated by an object within a magnetic field having a predetermined spatial gradient, for use in reconstructing an image representing said object, the method comprising the steps of:

acquiring a first set of first image data items using a first value of said predetermined spatial gradient for use in constructing a first image of said object;

acquiring a second set of second image data items using a second value of said predetermined spatial gradient which differs from said first value thereof for use in constructing a second image of said object wherein second image data items of said second set are acquired before acquisition of said first set is complete; and

generating third image data items according to first image data items, second image data items and the ratio of said different first and second values of said predetermined spatial gradient;

wherein the method further comprises the steps of:

generating first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

defining a first image boundary having a first image boundary vector $\vec{f}$ corresponding to the periphery of an image feature within the image frame of an image constructed according to said first real-space image data items;

defining a second image boundary having a first image boundary vector $\vec{r}$ corresponding to the periphery of said image feature within the image frame of an image constructed according to said second real-space image data items;

defining a third image boundary having a third image boundary vector being one of the first image boundary vector $\vec{f}$ and the second image boundary vector $\vec{r}$ to which is added an averaged-difference vector $\vec{d}'$ being an average of the difference $\vec{d} = \vec{f} - \vec{r}$ between said first image boundary vector and said second image boundary vector, the value of each element of said averaged-difference vector $\vec{d}'$ being determined as a weighted

average according to the expression:

$$\vec{d}'_j = \frac{1}{n}\sum_{i=0}^{n} w_i \vec{d}_{j-n/2+i}$$

where $\vec{d}'_j$ is the j[th] element of $\vec{d}'$, n is a predetermined number n of neighbouring elements to the j[th] element, and w_i are weights which may take values including 1;

segmenting said first real-space image data items such that first real-space image data items outside said first image boundary are set to a value of zero, and first real-space image data items inside said first boundary are retained; and

segmenting said second real-space image data items such that second real-space image data items outside said third image boundary are set to a value of zero, and second real-space image data items inside said third boundary are retained.

58. (Previously Presented): A method according to Claim 57 wherein said second image data items of said second set acquired before acquisition of said first set is complete are acquired from points in Fourier-Space which coincide with those points in Fourier-Space from which first image data items of said first set are acquired.

59. (Previously Presented): A method according to Claim 58 in which acquiring said first set of first image data items and said second set of second image data items includes the steps of:

(a) acquiring first image data items from a selected set of points in Fourier-Space; and

(b) acquiring second image data items from said selected set of points in Fourier-Space; and

(c) selecting a new set of points in Fourier-Space and repeating steps (a) and (b) in respect of said new selected set of points until acquisition of said first set is complete.

60. (Previously Presented): A method according to Claim 59 in which said selected set of points in steps (a) and (c) each forms a respective line of points in Fourier-Space wherein a set of points selected in step (c) forms a line of points being substantially parallel to a line of points formed by the selected set of points employed in preceding steps (a) and (b).

61. (Previously Presented): A method according to Claim 57 wherein the ratio of said different values of said predetermined spatial gradient is a constant value.

62. (Previously Presented): A method according to Claim 57 wherein the third image data items include pixel values of an image representing said object and are generated such that the position (x_3) of an image pixel in an image constructed according to the third data items is related to the positions (x_1 and x_2) of an image pixel in an image constructed according to the first and second data items respectively via the equation:

$$x_3 = \frac{\alpha x_1 - x_2}{\alpha - 1}$$

where α is the value of said ratio of said different values of said predetermined spatial gradient.

63. (Previously Presented): A method according to claim 62 wherein pixel intensity values (i_3) of an image pixel at position x_3 in an image constructed according to the third data items is related to the pixel intensity values (i_1 and i_2) of an image pixel in an image constructed according to the first and second data items respectively at positions x_1 and x_2 via the equation:

$$i_3 = (1 - \alpha)\frac{i_1 \cdot i_2}{i_1 - \alpha \cdot i_2}$$

where α is the value of said ratio of said different values of said predetermined spatial gradient.

64. (Previously Presented): A method according to Claim 57 wherein the ratio of said different values of said predetermined spatial gradient is substantially equal to -1 (minus one).

65 – 71. (Cancelled)

72. (Previously Presented): A method according to Claim 57 including the steps of:

generating first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

(a) comparing first real-space data items with second real-space data items;

(b) estimating whether or not data items so compared correspond with the same feature of the imaged object; and if not,

(c) iteratively repeating steps (a) and (b) in respect of real-space data items at least one of which differs from any of those compared in the previous iteration of step (a).

73. (Previously Presented): A method according to Claim 57 comprising the steps of:

generating first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

(i) selecting a first set of data items from said first real-space image data items;

(ii) selecting a second set of data items from said second real-space image data items;

(iii) comparing data items from said first set with data items from said second set;

(iv) defining a measure of similarity between data items so compared;

(v) estimating according to said measure of similarity whether or not said real-space data items so compared correspond with the same feature of the imaged object; and if not,

(vi) iteratively repeating steps (ii) to (v) in which at least one data item of said first set is compared to a data item of said second set with which it was not compared in the previous iteration of step (iii).

74. (Previously Presented): A method according to Claim 73 wherein said first set and said second set of data items comprises image pixel values corresponding to a group of pixels positioned within an image constructed according to said first and said second real-space image data items respectively whereby the pixel position of each element of the group neighbours the pixel position of another element of the group.

75. (Previously Presented): A method according to Claim 74 in which step (ii) includes selecting a subset of one or more data items from within said second set defining a subgroup of pixel values whereby the pixel position of each element of the subgroup neighbors the pixel position of another element of the subgroup when the subgroup comprises a plurality of elements, and in which step (iii) includes comparing pixel values of the first set with pixel values of the second set in which the pixel position of at least one element of said subset is displaced relative to the pixel position of the same element during the previous iteration of step (iii).

76. (Previously Presented): A method according to Claim 75 in which when the estimation according to step (v) is affirmative steps (ii) to (v) and (vi) are performed in respect only of elements within the subset in respect of which the affirmative estimation according to step (v) was obtained.

77. (Previously Presented): A method according to Claim 75 or 76 wherein each subset comprises a predetermined proportion of the total number of elements from within the set from which they are selected.

78. (Previously Presented): A method according to Claim 77 wherein the predetermined proportion is one half (1/2).

79. (Cancelled).

80. (Withdrawn): Apparatus for acquiring and processing Magnetic Resonance Image (MRI) data from Nuclear Magnetic Resonance signals generated by an object within a magnetic field having a predetermined spatial gradient, for use in reconstructing an image representing said object, the apparatus comprising:

image acquisition means for acquiring a first set of first image data items using a first value of said predetermined spatial gradient for use in constructing a first image of said object, and for acquiring a second set of second image data items using a second value of said predetermined spatial gradient which differs from said first value thereof for use in constructing a second image of said object, wherein said image acquisition means is arranged to acquire second image data items of said second set before acquisition of said first set is complete;

gradient control means for changing the value of said predetermined spatial gradient;

image processing means for generating third image data items according to first image data items, second image data items and the ratio of said different first and second values of said predetermined spatial gradient.

81. (Withdrawn): Apparatus according to Claim 80 wherein said image data acquisition means is arranged to acquire second image data items of said second set before

acquisition of said first set is complete from points in Fourier-Space which coincide with those points in Fourier-Space from which first image data items of said first set are acquired.

82. (Withdrawn): Apparatus according to Claim 81 in which said image data acquisition means is arranged to acquire said first set of first image data items and said second set of second image data items by:

(a) acquiring first image data items from a selected set of points in Fourier-Space; and

(b) acquiring second image data items from said selected set of points in Fourier-Space; and

(c) selecting a new set of points in Fourier-Space and repeating steps (a) and (b) in respect of said new selected set of points until acquisition of said first set is complete.

83. (Withdrawn): Apparatus according to Claim 82 in which said selected set of points in steps (a) and (c) each forms a respective line of points in Fourier-Space wherein a set of points selected in step (c) forms a line of points being substantially parallel to a line of points formed by the selected set of points employed in preceding steps (a) and (b).

84. (Withdrawn): Apparatus according to Claim 80 wherein said gradient control means is arranged to change the value of said predetermined spatial gradient such that the ratio of said different values thereof is a constant value.

85. (Withdrawn): Apparatus according to Claim 80 wherein the third image data items include pixel values of an image representing said object and are generated such that the position (x_3) of an image pixel in an image constructed according to the third data items is related to the positions (x_1 and x_2) of an image pixel in an image constructed according to the first and second data items respectively via the equation:

$$x_3 = \frac{\alpha x_1 - x_2}{\alpha - 1}$$

where α is the value of said ratio of said different values of said predetermined spatial gradient.

86. (Withdrawn): Apparatus according to claim 85 wherein pixel intensity values (i_3) of an image pixel at position x_3 in an image constructed according to the third data items is related to the pixel intensity values (i_1 and i_2) of an image pixel in an image constructed

according to the first and second data items respectively at positions x_1 and x_2 via the equation:

$$i_3 = (1-\alpha)\frac{i_1 \cdot i_2}{i_1 - \alpha \cdot i_2}$$

where α is the value of said ratio of said different values of said predetermined spatial gradient.

87. (Withdrawn): Apparatus according to Claim 80 wherein the ratio of said different values of said predetermined spatial gradient is substantially equal to –1 (minus one).

88. (Withdrawn): Apparatus according to Claim 80 wherein said image processing means is arranged to:

generate first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

define a first image boundary corresponding to the periphery of a feature within the image frame of an image constructed according to said first real-space image data items;

define a second image boundary corresponding to the periphery of said feature within the image frame of an image constructed according to said second real-space image data items;

define a third image boundary according to said first boundary and said second boundary;

segment said first real-space image data items according to said first image boundary;

segment said second real-space image data items according to said third image boundary.

89. (Withdrawn): Apparatus according to claim 88 wherein said image processing means is arranged to segment each of said first and said second real-space image data items such that: data items outside said first and third image boundary are discarded respectively; and, data items inside said first and third image boundary are retained respectively.

90. (Withdrawn): Apparatus according to any of Claims 88 to 89 wherein the third image boundary is defined according to an average of the difference between the first image boundary and the second image boundary.

91. (Withdrawn): Apparatus according to Claim 90 wherein the third image boundary is defined by one of the first image boundary and the second image boundary modified according to an average of the difference between the first image boundary and the second image boundary.

92. (Withdrawn): Apparatus according to Claim 90 wherein the first image boundary is defined by a first image boundary vector and the second image boundary is defined by a second image boundary vector and said difference between said first image boundary and said second image boundary is a difference vector being the difference between said first image boundary vector and said second image boundary vector.

93. (Withdrawn): Apparatus according to Claim 92 wherein the third image boundary is defined by a third image boundary vector being one of the first image boundary vector and the second image boundary vector to which is added an averaged-difference vector being an average of said difference vector.

94. (Withdrawn): Apparatus according to Claim 93 wherein the value of each element of said averaged-difference vector is determined as a weighted average of the values of:

a corresponding element of said difference vector; and,

a predetermined number of elements of said difference vector which neighbor said corresponding element.

95. (Withdrawn): Apparatus according to Claim 80 wherein the image processing means is arranged to perform the steps of:

generating first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

(a) comparing first real-space data items with second real-space data items;

(b) estimating whether or not data items so compared correspond with the same feature of the imaged object; and if not,

(c) iteratively repeating steps (a) and (b) in respect of real-space data items at least one of which differs from any of those compared in the previous iteration of step (a).

96. (Withdrawn): Apparatus according to Claim 80 wherein the image processing means is arranged to perform the steps of:

generating first real-space image data items from said first image data items, and second real-space image data items from said second image data items;

(i) selecting a first set of data items from said first real-space image data items;

(ii) selecting a second set of data items from said second real-space image data items;

(iii) comparing data items from said first set with data items from said second set;

(iv) defining a measure of similarity between data items so compared;

(v) estimating according to said measure of similarity whether or not said real-space data items so compared correspond with the same feature of the imaged object; and if not,

(vi) iteratively repeating steps (ii) to (v) in which at least one data item of said first set is compared to a data item of said second set with which it was not compared in the previous iteration of step (iii).

97. (Withdrawn): Apparatus according to Claim 96 wherein said first set and said second set of data items comprises image pixel values corresponding to a group of pixels positioned within an image constructed according to said first and said second real-space image data items respectively whereby the pixel position of each element of the group neighbors the pixel position of another element of the group.

98. (Withdrawn): Apparatus according to Claim 97 in which step (ii) includes selecting a subset of one or more data items from within said second set defining a subgroup of pixel values whereby the pixel position of each element of the subgroup neighbours the pixel position of another element of the subgroup when the subgroup comprises a plurality of elements, and in which step (iii) includes comparing pixel values of the first set with pixel values of the second set in which the pixel position of at least one element of said subset is displaced relative to the pixel position of the same element during the previous iteration of step (iii).

99. (Withdrawn): Apparatus according to Claim 98 in which when the estimation according to step (v) is affirmative steps (ii) to (v) and (vi) are performed in respect only of elements within the subset in respect of which the affirmative estimation according to step (v) was obtained.

100. (Withdrawn): Apparatus according to Claim 98 or 99 wherein each subset comprises a determined proportion of the total number of elements from within the set from which they are elected.

101. (Withdrawn): Apparatus according to Claim 100 wherein the predetermined proportion is one half.

102. (Withdrawn): Apparatus for reconstructing nuclear Magnetic Resonance images (MRI) or other images using the apparatus of Claim 80.

103. (Withdrawn): A computer system for use in image reconstruction according to the method of Claim 57.

104. (Withdrawn): The use of a computer system for image acquisition and processing according to the method of Claim 57.

105. (Withdrawn): A program for a computer comprising computer code which when executed on a computer system implements a method of Claim 57 using acquired image data.

106. (Withdrawn): A computer program product storing a program for a computer according to Claim 105.

107. (Withdrawn): An image generated using the method of Claim 57 or using any of the apparatus of Claim 80.

108. (Withdrawn): A Nuclear Magnetic Resonance Imaging system comprising apparatus according to Claim 80.

109. (Withdrawn): An image generated using the nuclear Magnetic Resonance Imaging system according to Claim 108.

110. (Withdrawn): An image generated using the computer system, or computer program or computer program product according to Claim 103, Claim 105 or Claim 106.

REMARKS

In the July 7, 2010 Official Action claims 57-78 and 80-110 were pending in the application, with claims 80 – 110 withdrawn and claims 57 – 78 rejected. Claim 57 has been amended above based primarily on the subject matter of previous claims 57, 65, 67, 69, 70 and 71. The expression for the value of each element of the averaged-difference vector $\vec{d}'$ is based on the description in the paragraph bridging pages 20 and 21, and in the paragraph bridging pages 41 and 42. Further, the feature of segmenting of the first and second real-space image data items is based on the description at page 40 lines 14 to 18. In view of the amendment to claim 57, claims 65 – 71 have been canceled above.

Claims 57 – 64 stand rejected under 35 U.S.C. §103(a) as allegedly "being unpatentable over Dong et al. (Rectification of distortion in MRI for stereotaxy (applicant submitted reference in IDS)) and in view of Haacke EM et al. (Magnetic Resonance Imaging (applicant submitted reference in IDS))." In regards to this alleged ground for rejection, the Examiner appears to have carried over the rejection to claim 79. Claim 79 is no longer pending in the present application and will not be addressed in the following response.

Claims 65 – 71 stand rejected under 35 U.S.C. §103(a) as allegedly "being unpatentable over Dong et al. (Rectification of distortion in MRI for stereotaxy (applicant submitted reference in IDS)), in view of Haacke EM et al. (Magnetic Resonance Imaging (applicant submitted reference in IDS)) and further in view of Pelagotti (US 2003/0035583)."

Claims 72 – 78 stand rejected under 35 §103(a) as allegedly "being unpatentable over Dong et al. (Rectification of distortion in MRI for stereotaxy (applicant submitted reference in IDS)), in view of Haacke EM et al. (Magnetic Resonance Imaging (applicant submitted reference in IDS)) and further in view of Murakawa (US 2001/0046321)."

These rejections, constitute all of the grounds set forth in the July 7, 2010 Official Action for refusing the present application. For the reasons given below, these grounds of rejection are overcome in view of the claim amendments presented above.

REJECTIONS UNDER 35 U.S.C. §103(a)

Claims 57 – 64 and 72 – 78 stand rejected under 35 U.S.C. §103(a)

In response the rejection of claims 57 – 64 and 72 – 78 the Applicants have amended independent claim 57 from which all pending claims, claims 58 – 64 and 72 – 78, variously

depend. Although the Applicants do not agree with the validity of the alleged grounds for rejection of the claims 57 – 64 and 72 – 78, the amendment to claim 57 fully overcomes the rejections.

Claim 57 now recites the feature of a "a third image boundary having a third image boundary vector being one of the first image boundary vector $\vec{f}$ and the second image boundary vector $\vec{r}$ to which is added an averaged-difference vector…". Further, claim 57 recites that "the value of each element of said averaged-difference vector $\vec{d}'$ being determined as a weighted average according to the expression:

$$\vec{d}'_j = \frac{1}{n}\sum_{i=0}^{n} w_i \vec{d}_{j-n/2+i}.$$

There is no disclosure in Pelagotti corresponding to or even hinting at these requirements.

For example paragraph [0032] of Pelagotti, referenced by the Examiner, discusses a motion vector, and not boundary vectors. Also paragraph [0032] does not discuss defining a third image boundary (the "third image" referred to in the penultimate line of paragraph [0032] of Pelagotti is not derived from the first and second images). Thus Pelagotti is largely irrelevant to the third image boundary requirements of claim 57.

In addition, claim 57 now recites "segmenting said first real-space image data items such that first real-space image data items outside said first image boundary are set to a value of zero, and first real-space image data items inside said first boundary are retained; and

segmenting said second real-space image data items such that second real-space image data items outside said third image boundary are set to a value of zero, and second real-space image data items inside said third boundary are retained." Again, there is no disclosure in Pelagotti corresponding to or hinting at these segmentation requirements.

The Examiner asks that "the criticality of these steps" be pointed out. The third image boundary requirements of claim 57 allow a smoother third boundary to be obtained. This in turn improves the segmentation from the rest of the image data of a feature of interest within the image frames of both the first and second images. Since corresponding image features within the first and second images typically shift to some degree due to the differing magnetic field gradients employed during image data acquisition, the corresponding boundaries of the feature(s) of interest within the two images will also shift. However, subsequent analysis of the first and second images is simplified by segmenting such that the

first real-space image data items outside the first image boundary are set to a value of zero, first real-space image data items inside the first boundary are retained, second real-space image data items outside the third image boundary are set to a value of zero, and second real-space image data items inside the third boundary are retained.

After segmentation, the third image boundary thus defines a boundary which better resembles the first image boundary than does the second image boundary, but is shifted by a similar amount as the second image boundary relative to the first image boundary. Noise or irrelevant data can be removed from both the first and second images, the presence of which can otherwise seriously hamper subsequent image processing of the features of interest within the images.

Thus in light of the amendments to claim 57, claims 57 – 64 and 72 – 78 are novel and nonobvious over Dong, Haake, Pelagotti, and Murakawa. Accordingly, inasmuch as the cited art provides no basis to arrive at the invention as instantly claimed, Applicants request that the rejection of claims 57 – 64 and 72 – 78 under 35 U.S.C. §103(a) be withdrawn.

Claims 65 – 71 stand rejected under 35 U.S.C. §103(a)

Applicants have canceled claims 65 – 71 above rendering the rejection of such claims moot.

CONCLUSION

It is respectfully requested that the amendments presented herewith be entered in this application. The amendments to the claims and accompanying remarks are believed to clearly place the pending claims in condition for allowance. Therefore, it is respectfully urged that the rejections set forth in the July 7, 2010, Official Action be withdrawn and that this application be passed to issue.

Early and favorable action on the present application is earnestly solicited.

Respectfully submitted,

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